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# Pathways to Expert Performance in Soccer

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## Abstract

In sport, deliberate practice theory has significantly impacted research on expertise and what has been known as talent/skill development. A wealth of data shows how practice volume distinguishes across groups that vary in their level of skill attained. This theory has led to models of skill development which vary in their emphasis on early engagement in sport specific deliberate practice as compared to later engagement, preceded by childhood structured play and diversified sport involvement. Deliberate practice theory has been widely studied in dynamic team sports, such as soccer. Here we review research from work we have conducted over the past six years, based on comparisons of highly elite male and female soccer players. We have evaluated prospectively and cross-sectionally, the developmental activities most related to successful transitions and adult success at the highest level of sport, as well as relations between these activities and technical and tactical skills development and indices of motivation. Our data show that successful, adult elite athletes, in the UK and Canada, are defined by what is termed the early engagement pathway. This is characterized by majority engagement in the chosen sport since early childhood, although not exclusive engagement, and engagement in relatively high volumes of self-directed play, in addition to high volumes of more formal, structured practice. We discuss issues with some of this research, including those related to measurement, and present ideas for future research based against the backdrop of the deliberate practice framework.

## Keywords

Authors, please supply 

## Introduction

The world of sport, and soccer in particular, offers researchers a valuable environment to study and learn about expert performance. This is primarily due to the vast worldwide participation base across cultures and sexes and, in the men's game at least, the very small proportion of players that reach the adult professional (expert) levels. Across multiple cultures and contexts, there has been a significant volume of research evidence showing what appears to be a necessity to engage in large volumes of soccer-specific activity during youth development (e.g., Ford et al., 2012; Ford, Ward,

Hodges, & Williams, 2009; Ford & Williams, 2012; Hugaasen & Jordet, 2012; Hornig, Aust & Gullich, 2016; Zibung & Conzelmann, 2013). This research was catalyzed by Ericsson, Krampe, and Tesch-Römer's (1993) theory of deliberate practice and a slew of studies designed to test the importance of high volumes of practice for athlete success. These research findings have, at least in part, exacerbated a trend toward the recruiting of players at increasingly younger ages, with a view to optimizing the volume and quality of practice accumulated during development (Côté, Coakley & Bruner, 2011).

The overall efficacy of this early selection approach for sport expertise development, as well as its psycho-social impact on players has been questioned (e.g., Côté & Erickson, 2015). Current debates in sport expertise research focus on the question of whether high volumes of sport-specific activity are indeed required during childhood and, if so, what these activities should look like and what might be some of the costs of early intense specialization in sport. In this review, we evaluate current research in deliberate practice related to sport development generally and success in soccer more specifically. In addition to a brief review of some of the prevailing ideas, we present some of our own data on this topic, collected over the last six or seven years and offer some thoughts regarding future study of elite athletes with respect to evaluation of practice and developmental sport activities.

### **Deliberate Practice and Play in Soccer**

Much of the scientific study of expertise development in sport over the past 20 years stems from Ericsson et al.'s (1993) classic study of expert musicians, in which a strong, positive relationship between cumulative hours in “deliberate practice” and musical attainment was highlighted. Although the theory has been revised over the years (e.g., Ericsson & Pool, 2016), the general idea is that deliberate practice activities are those that are structured or prescribed by a coach/teacher, engaged in for the primary purpose of improving performance, are not always inherently enjoyable, and require full attention and high levels of effort. Solitary practice was the prototypical form of deliberate practice, given the intense, purposeful, self-directed nature of the activity. However, in interactive sports, such as soccer, field hockey and wrestling, where domain-specific practice can really take place only in the company of others in order to match perceptual-motor-cognitive demands of the sport, interactive “team practice” has been shown to be a key discriminator of performance attainment (e.g., Ford et al., 2009; Helsen, Starkes & Hodges, 1998; Hendry, Williams, & Hodges, 2018; Hodges & Starkes, 1996; Hodges, Kerr, Starkes,

Weir, & Nananidou, 2004; Zibung & Conzelmann, 2013).

The importance of deliberate practice has been widely recognized as a central component to the development of expertise in sports (see Baker & Young, 2014; Ford, Coughlan, Hodges, & Williams, 2015). However, there has been increasing critique of deliberate practice by several prominent researchers (e.g., Côté, Murphy-Mills, & Abernethy, 2012; Hambrick et al., 2014; Macnamara, Hambrick, & Oswald, 2014). Some have criticized the theory on conceptual grounds, arguing that the linear relationship between practice with attainment is overly simplistic and does not account for the multi-dimensional and dynamic nature of athlete development (Collins & Macnamara, 2017). Meta-analyses have cast doubts on the efficacy of deliberate practice to explain expertise, with practice hours (although not solely activities which meet Ericsson’s current criteria of deliberate practice), accounting for 20% of the variance in sport expertise, based on comparisons across skill class (Macnamara, Hambrick, & Oswald, 2014, 2018). Within a skill class of elite sports performers, the variance accounted for by practice was as low 1% (Macnamara, Moreau, & Hambrick, 2016). One explanation for this finding relates to the idea that deliberate practice may be circumvented by participation in other, potentially related sports, during childhood (5-12yr) or by participation in play-type activities rather than formal, structured practice (e.g., street soccer/hockey, Côté, Baker & Abernethy, 2007; Côté et al., 2012). These arguments are outlined within the Developmental Model of Sport Participation (DMSP; Côté, 1999; Côté et al., 2007, 2012).

The DMSP was formulated as a counterpoint to deliberate practice theory and highlights childhood (5-12 yr) as a particularly important time period for long-term athlete skill development and continued engagement in sport (see Côté, et al., 2012). Based largely on the type, intensity, and variety of sport experiences during childhood, according to the DMSP, there are two primary pathways towards sports expertise: (1) early specialization, involving high volumes of domain specific deliberate practice

in one sport from an early age; and (2) early diversification/sampling, involving participation in a variety of different sports and play activities during childhood and later specialization. In soccer, play activities relate to unorganized, self-led soccer activities conducted without a coach, including games, general kick around or individual play; Hendry & Hodges, 2018). Debate persists as to which pathway is most beneficial for the attainment of expertise and related, positive youth sport development (e.g., Côté et al., 2012; Ford et al., 2015). Some researchers claim distinct benefits from sampling a variety of different sports and play experiences during childhood that are associated with skill development (e.g., Côté et al. 2012), as well as decreased risk of drop-out (Gould & Maynard, 2009) or injury (Post et al., 2017) and potentially increased intrinsic motivation in later years (Côté, Lidor & Hackfort, 2009, Côté et al., 2012). Others present evidence to show that earlier specialization in the primary domain frequently characterizes individuals who attain eventual expertise and that time spent in other activities does not enhance chances of success (e.g., Ford et al., 2012; Helsen et al., 1998; Law, Côté, & Ericsson, 2008; Ward, Hodges, Starkes & Williams, 2007; Zibung & Conzelmann, 2013) 

As an amalgam of both DMSP pathways, “the early engagement hypothesis” (Ford et al., 2009) incorporates elements of both  the early specialization pathway and early diversification/sampling pathway. Emphasis is placed not only on early engagement in practice but also engagement in sport-specific play-type activities (e.g., street soccer). Support for this pathway comes from study of developmental pathways of elite youth soccer players. The successful elite players, compared to age-matched controls, engaged in more soccer specific practice and more informal “play” activities during childhood than non-elite youth players (Ward et al., 2007). Follow-up of these elite players showed that only time in soccer-specific play during childhood distinguished players that later achieved a professional contract at age 16 yr from those who did not (Ford et al., 2009).

In the remainder of this article, we present findings from a series of studies conducted by our group over approximately the last 6 years, where we have been evaluating evidence concerning the relations between the various developmental pathways and adult success in elite male and female soccer. In addition to trying to capture expertise differences based on sport activities, we also investigate relationships between early developmental activities (including practice and play and sport diversity) and different types of skill and motivation. Acknowledging some of the limitations of sports expertise research to date, which has not moved too far beyond counting practice hours, we also provide some suggestions to help better assess the types of activities which best engender success.

### The Early Majority Engagement Pathway

In a five-year prospective study, of elite male youth soccer academy players in the UK, we were able to ascertain which developmental activities discriminated across three skill-based transitions by subdividing these athletes into three groups (Hendry & Hodges, 2018). Academy-only players never progressed beyond the youth academy at age 14/15 yr. Youth-professionals successfully transitioned and received a professional youth contract at ~16/17 yr, but did not transition to adult professional at 19/20 yr (latter group = Adult-professional).

The players who progressed to youth professional status at ~16 yr amassed more hours in soccer practice during childhood than those Academy-only players who did not (Hendry & Hodges, 2018). Hours in self-led activities outside of formal practice, what we termed soccer play, did not differentiate across the groups statistically, despite the professional groups engaging in ~600 more hours of play during childhood in comparison to Academy-only players (c.f., Ford et al., 2009; Ford & Williams, 2012). However, hours in soccer play did differentiate the top groups in our study (Youth versus Adult-professional). The later successful Adults also spent a greater proportion of time in play relative to practice during childhood, than those who failed to transition.

Consistent across all skill groups, these elite youth players followed an early majority engagement pathway, in which they invested the majority of their sport-time in soccer practice and play from an early age (~5 yr), in comparison to multi-sport involvement. Importantly, only two players specialized solely in soccer from an early age, neither of which advanced to professional status. Moreover, no players met the criteria of specialization recently proposed by Post and colleagues (2017) involving engagement in more hours of practice per week than the child's current age for a minimum of 9 months per year. Therefore, although early majority engagement defined these youth elite athletes, these athletes were not specializing only in soccer, and this early pattern of engagement was not a distinguishing feature of later success. In a separate cross-sectional comparison of elite (National team) and sub-elite (Varsity; Canadian university) adult female soccer players, we showed a similar pattern of results, with both groups reporting data  consistent with the early majority engagement pathway outlined above (Hendry, Williams, Ford & Hodges, in review). Again, these high-level skill groups were not distinguished based on their initial involvement in soccer, leading to the conclusion that early, majority engagement in one's chosen sport, in this case soccer, is a necessary, though not sufficient condition for success.

We suspect that for sports with a large participation base, high perceptual-motor-cognitive demands, and limited opportunity to attain elite or professional status (e.g., Canadian ice-hockey, Southern Hemisphere rugby, or the Quarterback position in American Football), elite players will likely follow a developmental pathway consistent with the early majority engagement pathway. In other sports, where the basic physiological capabilities of an athlete may take precedence over perceptual-motor-cognitive skill (e.g., NFL linebacker, skeleton bob-sleigh; Bullock et al., 2009), more diversified sport pathways will likely be seen (e.g., Côté, et al., 2012).

At one level, the necessity of early engagement in practice activities is consistent

with the monotonic benefits assumption outlined within deliberate practice theory (Ericsson et al., 1993). However, the fact that hours in soccer play repeatedly discriminates across skill groups at the highest levels questions the overall accuracy of deliberate practice theory in terms of the type of activities most related to success (Ford et al., 2012, 2009; Haugaasen & Jordet, 2012). Part of the reason for this discrepancy is likely related to the varied definitions and measurement of practice and play activities across studies (including our own). Researchers have distinguished both activities on the basis of intentions (i.e., fun/enjoyment vs. improvement) as well as whether the activities are coach or self-directed (see Côté & Erickson, 2015; Ford et al., 2015; Hendry & Hodges, 2018). There are several problems with distinguishing play and practice using the current operational definitions. It is questionable whether any childhood activities are engaged in for the primary purpose of improvement (at least from the child's perspective). Trying to untangle motivations at young ages is difficult and likely leads to considerable difficulty in recall, especially when practice histories are collected retrospectively from now elite adults. Moreover, ratings of enjoyment within a sport or domain are variable, often changing on a daily basis, irrespective of how an individual might perceive the relevance of the activity to performance improvement (Hodges & Baker, 2011; Hodges et al., 2004). Proponents of the constraints-based or non-linear pedagogical approaches to skill acquisition suggest that skills emerge as a by-product of the unique environmental, individual, and task constraints, often in the absence of specific intentions (e.g., Chow, Davids, Renshaw, & Button, 2013). For example, playing 3v3 street soccer in a limited area, on an uneven surface, may facilitate the development of a player's perceptual-motor-cognitive capabilities which could ultimately lead to better close control and decision making.

Play and practice have also been distinguished based upon the coach-directed and structured nature of the activity. Formal or coach-led/structured practice has often been distinguished from informal, self-led/low

structured, peer-based “play.” While this distinction can be useful in aiding recall, it does not necessarily have the fidelity to identify which developmental activities within these broad categories of practice and play aid skill development. Coach-directed practice will likely have aspects of play (such as playing a game without interruption) and non-coach led play will also have aspects of practice (such as trying to practice unusual moves or shots because there is no fear of evaluation or correction). Thus, although dividing childhood activities on the basis of whether they are primarily coach or child-led may serve a practical methodological purpose, at a theoretical level, there is a need for researchers to consider other ways of assessing key developmental activities. This might be through the assessment of the underlying perceptual-motor-cognitive aspects of activities that are likely to facilitate the development and transfer of soccer skills to competition performance. Soccer specific activities which are more closely aligned with competitive match play will likely be most important for success. In this respect, recent analysis of practice microstructure (e.g., Low, Williams, McRobert, & Ford, 2013; Hornig et al., 2016), practice decision points (O’Connor, Larkin, & Williams, 2017), and/or practice structure with respect to variability (e.g., Buszard, Reid, Krause, Kovalchik, & Farrow, 2017) offer promise for future work.

In addition to definitional issues, there are issues associated with the methods of collecting these developmental data using retrospective practice history questionnaires. Surprisingly, there is little published work to date that provides guidelines with respect to acceptable parameters of error estimates. Given that we and other researchers have both current and retrospectively recalled practice and play data collected from various athlete groups, there is now a need to establish some criterion of validity and reliability associated with these estimates. Although we often do not care about the absolute hours in activities, but rather comparative estimates across skill groups and time, having some knowledge of the degree to which estimates might be inflated would be

useful in establishing validity guidelines and to make more accurate statements about differences.

### **Relations Between Developmental Practice Activities and Specific Skills**

Given the proclivity for expert male soccer players to engage in higher volumes of soccer play than practice during childhood and accumulate more hours in play than their less accomplished peers, one might suggest finding ways of maximizing opportunities for street or playground soccer during childhood. Similar suggestions have been made based on the early sampling pathway, with the proposal that high amounts of deliberate play during early childhood provide a broad base of motor and cognitive experiences that can be later applied to facilitate development of the principle sport (Côté et al., 2009, 2012). Play is thought to give athletes opportunities to experiment with new ideas and techniques that may not be afforded in more formal, coach-led, deliberate practice environments (Araújo et al., 2010). As a counterpoint, others have argued that the benefits of engagement in play are overstated (MacNamara, Collins, & Giblin, 2015). Although these authors acknowledge some psychosocial benefits of play, they assert that cognitive and motor skill development is best served via effective practice design, instruction, and feedback from expert practitioners (see also Ericsson et al., 1993). Related to this point, there is also the strong possibility that play proves to be beneficial only to later success in that it adds to the volume of “practice” acquired in the sport, rather than producing any specific perceptual-motor-cognitive conditions that benefit the development of soccer expertise (Hendry & Hodges, 2018).

To determine whether childhood involvement in play was related to specific skills, such as creative and tactical awareness and technique, we gathered evaluations from expert coaches of various cognitive and motor skills considered fundamental for success in soccer. These **evaluations** were then related to estimates of childhood (5-12 yr) and career (5-16 yr) deliberate play and practice amounts

(Hendry, Williams & Hodges, 2018). Although the sample size was small, data derived from professional players (both Youth and Adult; see above) showed moderate positive relationships between coach-led soccer practice and technical, tactical and creative skills. However, there were no significant positive relationships between self-directed play and any skill measure. These findings align with assertions made by prominent researchers (e.g., Ericsson & Pool, 2016; MacNamara et al. 2015) that motor skills are best developed with the supervision and guidance of expert practitioners. Despite the lack of positive correlation between soccer play with skill ratings, it is important to refrain from discounting the importance of soccer play in developing soccer expertise especially given findings that elite youth players tend to engage in greater volumes of play during development than practice (e.g., Ford et al., 2009; Hendry & Hodges, 2018; Roca, Williams, & Ford, 2012; Williams, Ward, Bell-Walker, & Ford, 2012). In this respect it is likely that self-directed soccer play allows young players to develop some of the foundational elements of skilled performance. However, for elite youth soccer players on the pathway towards professional status, our data suggest that access to high quality soccer practice (e.g., best coaches, working with the best players, in the best facilities) provides the most beneficial learning environment, in comparison to play, since practice was generally most associated with technical and tactical skill development.

**One explanation** for the lack of positive correlations between soccer play with skill is that soccer play does little more than add to the overall volume of soccer activity. Although volume is important, it is not sufficient for high level skill development (which is the very crux of deliberate practice theory). Very little is known about the specific nature of play, at least in terms of the underlying motor learning principles fostered by play in a sporting context. Yet, there is often an assumption within the sports expertise literature that play is more variable in nature than practice, providing more opportunities for decision making and autonomy (see Côté & Erickson, 2015). To date, there is

little to no evidence to support this claim, despite some strong arguments concerning the benefits of unstructured play based upon the constraints-led approach (e.g., Araújo et al., 2010). Measuring the structure of play is likely challenging. For example, it is equally plausible that play may elicit conditions that are relatively low in variability, (e.g., practicing keep ups, or kicking the ball against a wall to practice control) as it will present more enriched, game-based conditions that are inherently high in variability (e.g., opposed environment mimicking the underlying structures of match-play). Another reason why childhood play shows up as an important variable may be because play amounts are a proxy measure of early interest and motivation in the sport. As such, individuals who go on to succeed show high levels of play in early development, because they are inherently interested in the sport. In this way, play could be an important driver of better quality practice across development.

### **Relations Between Developmental Practice Activities and Current Motivation**

Motivation is considered a primary influence on the emergence of expertise and is viewed as being central to deliberate practice (Baker & Horton, 2004; Baker & Young, 2014; Ericsson et al., 1993). Learners must be willing to invest maximal effort over an extended period of time in deliberate practice activities, which are not necessarily inherently enjoyable (Ericsson & Towne, 2010). Different types of motivation are required to engage in deliberate practice activities since they are often described as being challenging and at times mundane, or at least not immediately gratifying (e.g., Coughlan, Williams, McRobert & Ford, 2014; Ericsson et al., 1993; yet see Hodges et al., 2004; Ward et al., 2007). Ericsson (1996) points out that individuals placed into talent development programs by parents may not be motivated in the activity initially. However, over time, as skill and feelings of competency develop, the child develops more self-determined forms of motivation (including intrinsic motivation) to improve and invest time in practice. This suggestion contrasts with a postulate made by

Côté and colleagues (2012) that “high amounts of deliberate play during the sampling years (~5-12 years) builds a solid foundation of intrinsic motivation...and promotes intrinsic regulation...” (pp. 278–279). Both predictions are likely valid and may reflect the complexity of reasoning underpinning the types of motivation required to engaged in sustained, high intensity practice.

The multifaceted nature of motivation involved in practice engagement can be situated within Self-Determination Theory (SDT; Deci & Ryan, 1985; Ryan & Deci, 2017). SDT is a meta-theoretical framework which assumes that motivation lies along a continuum of self-determination. According to SDT, the interaction of personal and societal factors can influence the degree to which one’s basic psychological needs (competence, autonomy, and relatedness) are met. When these basic needs have been met, an individual becomes autonomously motivated (i.e., more self-determined, engaging in an activity through a sense of volition), whereas when these needs are thwarted, motivation is controlled (i.e., less self-determined, engaging in an activity through a sense of obligation or pressure) or the individual becomes amotivated (i.e., lacks motivation).

In two related studies of elite male youth soccer players in the UK and Canada (13 – 17 yr), we failed to show any positive associations between time in childhood play and indices of self-determined motivation (e.g., autonomous & controlled motivation; Hendry, Crocker & Hodges, 2014, Hendry, Crocker, Williams & Hodges, in press). However, we did find that within the older, elite players (Under 17 yr), more practice hours accumulated in the elite academy setting were related to lower self-determined motivation (Hendry et al., 2014). Moreover, this U17 group was also defined by less self-determined motivation as compared to the U13 and U15 yr age groups. In a follow-up study, using a mixture of cross-sectional and prospective methods, motivation was shown to become less self-determined (i.e., more controlled and less autonomous) in older elite level players (i.e., from U15 to U17 yr). This was also shown cross-sectionally (i.e., current

U15 vs U17 yr), but was not shown across the same time period for younger players (U13 - U15 yr), in younger elite groups (e.g., U13 and U15 yr), nor in U17 yr, non-elite players. Drawing from educational research (e.g., Deci, Koestner & Ryan, 2001), this shift towards less self-determined forms of motivation at this age range is likely related to the external rewards associated with the attainment of professional status (e.g., status, financial reward, fame). Despite this shift, it is important to note, that for measures of autonomous motivation, the elite players always scored higher than the non-elite, regardless of age. Thus, the older age group players appear to be exhibiting a co-existing motivational profile, in which players on the cusp of attaining professional status are motivated through more (e.g., inherent interest in soccer) and less self-determined forms of motivation (e.g., winning and rewards associated with achieving professional status). Such profiles have been noted elsewhere and have been described as being both beneficial to, and a consequence of, highly competitive sport involvement (e.g., Gillet, Berjot, Vallerand, Amoura, & Rosnet, 2012; Gillet, Berjot, & Gobancé, 2009; Hardy et al., 2017; Ratelle, et al., 2007).

**There were** also significant positive associations between controlled motivation and hours in soccer practice across the last 2.5 years in the U17 elite players (but not practice amounts overall). It is likely that this relationship reflects players’ closer proximity to critical selection ages and the increased playing demands placed on these older youth players (e.g., Cook, Crust, Littlewood, Nesti, & Allen-Collinson, 2014). Overall, our data show that shifts towards less self-determined motivation occurred as a function of age and skill. However, elite players still scored higher on self-determined motivation measures than the non-elite players. This occurred despite elite players accumulating approximately double the number of hours in childhood soccer practice than their peers. These findings highlight the complex nature of motivation in youth sport, suggesting that changes in motivation may have less to do with practice volume or activity type, than they do

with outcomes associated with sport (such as professional status).

### **Developmental Activity Challenge as an Index of Activity Quality**

In the research we have presented thus far, play and practice have been largely distinguished from each other on the basis of intention (e.g., fun or improvement) and organization (e.g., coach-led or self-directed). While such distinctions have proved useful in helping us better understand relationships between activity quantities with expertise, they do not necessarily address the issue of activity quality. To tackle this issue, we asked National team and highly skilled Varsity women soccer players in Canada to provide ratings of perceived challenge when recalling various practice related activities. We included measures of challenge based on the challenge point framework (Guadagnoli & Lee, 2004). Accordingly, there is a theoretical optimal challenge point that emerges when the constant degree of difficulty inherent in the task, is equal to, or slightly higher, than the skill of the learner relative to the task. At this point, the learner is able to process an optimal amount of information thus maximizing the potential for learning. National players viewed play and, to an extent, competition as more challenging during development than Varsity players. Across both groups, competition was viewed as being the most challenging activity and play the least. Importantly, although total soccer practice amounts did not discriminate across these highly skilled groups, National players engaged in a greater volume of practice (and play) rated as being moderate to high in challenge than the Varsity players. These data lend promise to sensitive and relatively simple ways of retrospectively (and concurrently) measuring developmental sports activities that capture activity quality. Such measures might obviate the need for distinctions to be made based on activities (such as practice and play), with challenge being the primary determinant of whether any activity will contribute to skill development. However, further research is required to unpack the specific nature of challenge and any relationships with the

development of different aspects of soccer skill. Of course, the activity still has to be relevant to the game and the skills required in competition. **In deliberate** practice theory, competition is seen as a work activity, something that is time constrained, externally rewarded, and that offers limited learning opportunities (Ericsson et al., 1993). Thus, competition is thought to contribute little to expertise attainment. Indeed, competition or match-play amounts have frequently failed to distinguish across skill groups (e.g., Hodges & Starkes, 1996; Helsen et al., 1998). However, viewing sport competition as work, may be a conceptualization that fails to translate from music to sport, since competition is generally rated as being a highly enjoyable and improvement-relevant activity (Ward et al., 2007). Our data suggest that high quality competition (as operationalized through challenge) could be an important discriminatory variable (Abernethy, Farrow & Berry, 2003; Cook et al., 2014; Singer & Janelle, 1999). In soccer, competition is often viewed as an extension of practice, providing players with experiences that are not easy to simulate in practice (e.g., psychological preparation, playing against unfamiliar opposition; Cook et al., 2014; Holt & Dunn, 2004). Given that the total number of competitions/games is typically controlled by soccer governing bodies, it makes sense that, for this activity to have any discriminatory power, we need to look beyond just measuring amount of competition experience, but rather the type of experience.

### **Conclusions**

Elite male and female soccer players in the UK and Canada followed an early engagement pathway, characterized by primary involvement in soccer specific practice and play from an early age in comparison to multisport engagement. Although soccer play amounts in childhood distinguished across players who successfully transitioned or made it to elite levels, in both men and women's soccer, it was deliberate practice type activities that were most related to the development of skills fundamental to elite status in soccer, particularly those perceived as moderate to high in challenge. Despite the

discriminability of these measures of practice and play, we recognize the need to create more refined measures of practice quality and to better validate current, retrospective methods of collecting practice history data.

For future research, the gold standard method will be to collect longitudinal data—either during critical time periods in development (such as adolescent transitions so that factors related to drop out can also be probed), or wherever possible, from initial sport entry through to defined “elite status” in adulthood. Assessment at the initial entry level would then allow determination of how important early individual differences in “skills” are in leading to later success (when practice amounts are matched across individuals) and whether certain individuals appear to show more responsiveness to training (and why). Although it is clearly established that practice is a critical component to elite success, we still are unsure as to how much initial precocity matters and the variables potentially responsible for these differences. Likely there is some contribution of, and interaction between, initial early prowess/evidence of skill and extended exposure to quality practice (Ford, Hodges & Williams, 2013).

One aim would be to encourage clubs or academies to ascertain practice/play data from their players on a yearly basis, so that there are multidimensional measures of player characteristics (e.g., height, weight, birth date, sprint times coupled with these practice measures) across multiple time points. Many developmental institutions/sport academies also have data on variables related to practice microstructure, derived from performance analysis tools (e.g., game-tracking systems like Prozone, now run by STATs; <https://www.stats.com/tag/prozone/>) and load monitoring devices (e.g., GPS and heart rate). These devices and software can provide rich data sets to facilitate understanding of the specific practice conditions most related to game specific performance. This type of monitoring approach has rarely been used by researchers to assess the specific practice conditions most related to success in upcoming games or tournaments (e.g., for a 4-year Olympic cycle as opposed to the next game or even current season). Practice

conditions designed to optimize long term development and learning are not always compatible with those that bring out the best currently observed performance in practice or competition (Guadagnoli & Lee, 2004; Hendry & Hodges, 2013).

By increasing the fidelity through which we can assess practice and contribute to the understanding of elite performance, statistical techniques that account for the multi-faceted and complex nature of expertise will be required. Researchers from the University of Berne have used a person-oriented statistical approach (e.g., Bergman & El-Khoury, 2003) to analyze their multidimensional data set, corresponding to measurement of developmental factors related to soccer success (e.g., Sieghartsleitner, Zuber, Zibung & Conzelmann, 2018; Zibung, Zuber & Conzelmann, 2016). A person-oriented approach affords opportunity to assess the non-linear interaction of variables within a single individual that cannot be accomplished using the general linear models commonly used in sport expertise research. A study of the developmental activities that appear to best facilitate success in sport, in particular soccer, has gained a lot of traction since Ericsson et al. (1993) published their theory of deliberate practice. As should be clear from this review, the data serve to highlight the importance of engagement in domain specific activities from an early age, but in soccer, this includes activities which would fit definitions outside of traditional notions of deliberate practice (such as play). As to the issue of early specialization versus diversification, it appears that elite soccer players engage in a hybrid of both these sport pathways, participating in a number of sports, but with the majority of their time in soccer specific practice and play from an early age.

### Authors' Declarations

The authors declare that there are no personal or financial conflicts of interest regarding the research in this article.

The authors declare that they conducted the research reported in this article in accordance with the [Ethical Principles](#) of the Journal of Expertise.

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